HOW TO CONTROL BILLBUGS

DESTRUCTIVE TO CEREAL AND FORAGE CROPS

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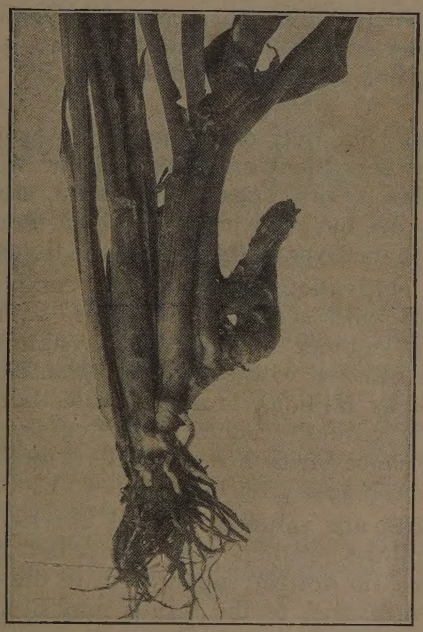

FARMERS' BULLETIN 1003
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
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Washington, D. C. January, 1919

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

BILLBUGS DESTROY OR INJURE corn, wheat, rye, barley, oats, timothy, blue grass, Bermuda grass, Johnson grass, rice, sugar cane, peanuts, and chufa. The best-known form of injury is corn leaf perforation.

The principal losses are caused by combined injury by the adult billbugs and their young or larvæ. The heaviest losses are probably in hay and pasturage.

Billbugs have only one generation yearly and are generally dependent on grass sods or wild sedges and rushes. Corn, sugar cane, chufa, and timothy probably are our only crops in which they can perpetuate themselves within the plant tissues.

Clean cultivation, especially the complete elimination of wild sedges and rushes, suitable crop rotations, summer or early fall breaking of cultivated or infested wild sods, early planting of crops menaced by billbugs, and the protection of birds, especially ground feeders, including the bobwhite and the shore birds, are efficient methods for preventing crop losses by billbugs.

Parasites are valuable natural checks, but their work follows, rather than prevents, crop loss. Therefore, do not rely upon them to the neglect of control measures, or the results may be disastrous.

Cooperate with your neighbors in active measures for destroying the billbugs.

HOW TO CONTROL BILLBUGS DESTRUCTIVE TO CEREAL AND FORAGE CROPS.

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HOW BILLBUGS INJURE CORN, GRAINS, AND GRASSES.

THE CONTROL of billbugs destructive to corn, wheat, and other cereals and to forage plants is a matter of vital importance to many farmers throughout the country. The presence of the billbugs in cornfields usually is first made known by the appearance of rows of holes in the corn leaves. These holes are made by the beetle before the unrolling of the leaf. The principal injuries to this crop occur in the spring when the beetle reduces the stand or shortens the season for replanted corn or both.

Injuries to cultivated grasses and to small grains probably are much greater than to corn, although unnoticed except in extreme cases.

The havoc wrought by the large, swamp-grass infesting billbugs shows the need of caution in planting corn near marshes, especially on recently drained land, where bullrushes, sedges, and other coarse, wild grasses grow. To bring this ground into corn production without loss, precede the corn planting by one year's planting of crops which are distasteful to billbugs. Billbugs in the adult and larva stages feed normally on the same species of plant, and do not usually travel much.

Over a large area showing serious infestation in Illinois it was found that billbugs injured 50 to 75 per cent of the timothy corms in certain fields, whereas in the younger, 2-year-old timothy sods only

10 to 20 per cent of the corms were injured. Of infested corn hills, 33 per cent failed to produce ears, some fields yielding only 20 to 45 bushels per acre where the normal yield was 80 bushels.

The larger billbugs may be sufficiently abundant in reclaimed swamp land to destroy two or three complete replantings of corn, while the smaller kinds in timothy fields turned down for corn rarely destroy more than about 50 per cent of the first replanting, and do little subsequent injury.

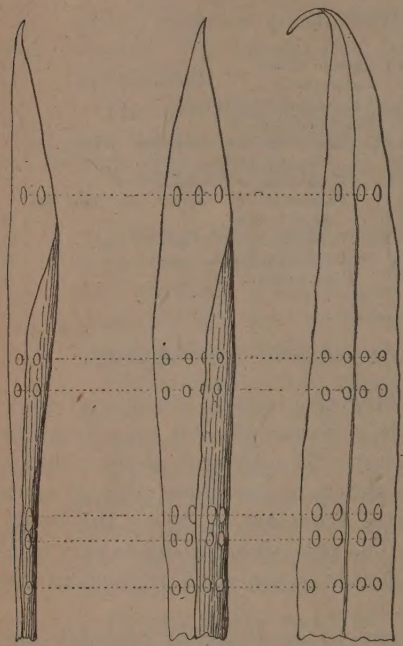

FIG. 1.—Diagrammatic figures showing rolled corn leaf with billbug punctures in it and the same leaf unrolled to show the characteristic row of holes and how they are produced.

The losses in corn usually are caused by the adults, except in the case of the maize billbug and the "curlew bug," the injuries of which are caused by both adults and grubs. Each transverse row of holes in a corn leaf (fig. 1) results from a single puncture made by a beetle through the layers of a rolled-up leaf. The corn plants may be deformed in two ways: First, the perforated leaf, by falling or twisting, may interfere with the growth of the following leaves (fig. 2); and, second, injury low down on the stalk may cause sprouting or suckering (fig. 3). Loss by the former type of injury may be reduced by clipping off promptly the deformed leaf, but loss by the latter type is irreparable.

While injury to corn usually takes place early, damage may appear after the corn is 4 feet high.

Injury by adults to blue grass appears in the stem between the roots and the second joint, as numerous punctures, ragged as if the fibers were torn apart, but often there is no evidence of feeding by the beetle on the soft central tissue, or even of disturbance of this tissue.

Other losses are caused by extensive feeding of the young or grubs on the fibrous roots of grasses and grains, within timothy corms, and to some extent within the stems of small grains (figs. 4 and 23). Injury to small grains by the grubs occasionally is shown as bleached-out heads with shriveled or no kernels, areas in margins of fields having from 10 to 68 per cent of the heads white on this account.

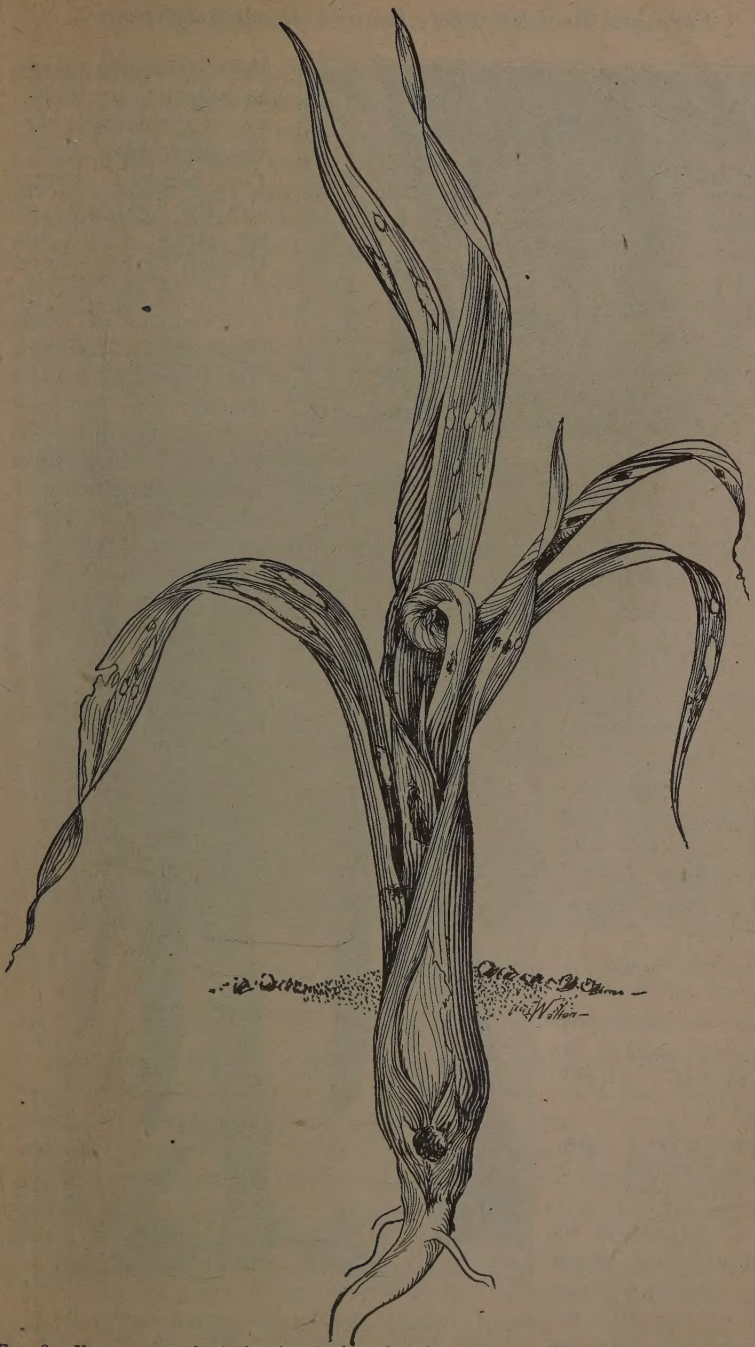

FIG. 2.—Young corn plant showing leaf perforations and the "bud" twisted by the pushing of growing leaves caught in the injured tissues. Cutting off of such bent or twisted buds promptly is sometimes profitable.

FIG. 3.—Corn plants crippled irreparably by the maize billbug. Plants injured thus spend their remaining vitality in suckering profusely and can not produce an ear.

More commonly injury is indicated by breakage of the straw as harvest approaches (fig. 5). This breakage resembles the "lodging" of the straw where the Hessian fly has caused injury in the spring. The manner of work, however, is different. The fly makes a dent in the outside wall without chewing the stem fiber, but the billbug grubs eat away the interior of the stem so that the remaining shell crushes with the weight of the top or with the wind. These bored stems are left packed with débris by the billbug grubs.

Grub injury has been observed in blue-grass stems as a burrow either upward or downward from the egg cell. These burrows occasionally are as much as 15 or 18 inches in length. When too large to continue in the original stems the grubs go down to the root stocks and fibrous rootlets to complete their growth.

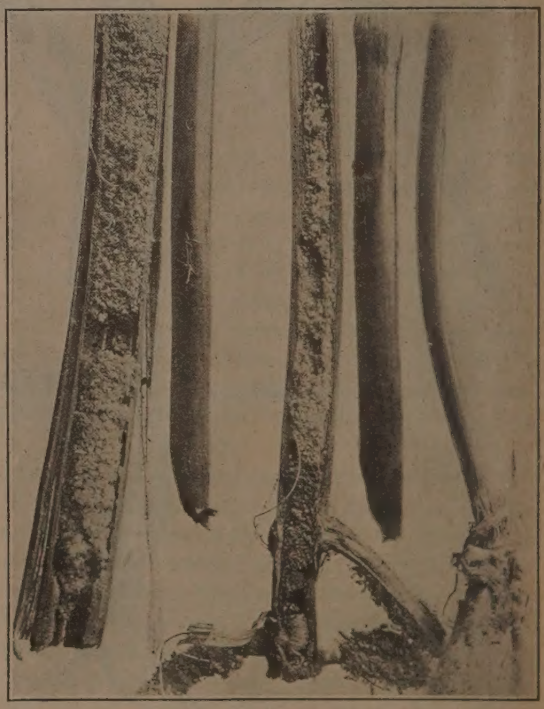

FIG. 4.—Work of the blue-grass billbug, showing punctures in the unsplit straws where fibers are frayed, and the frass-packed excavations in the split stems. A larva is shown in the base of the central stem.

GENERAL DESCRIPTION OF BILLBUGS.

The parents of the billbug grubs are beetles varying from one-fifth to about an inch in length, each of

which possesses a long snout or bill which carries at its tip a pair of strong jaws with which the beetle chews its food and bores the cells in which its eggs are laid. The beetles have extremely hard shells, which often are more or less pitted and ribbed along the back. They vary in color from clay yellow through reddish brown to jet black, but are often so covered with the soil in which they have been boring that they resemble small animated lumps of earth. When disturbed a beetle will draw in its legs, fold its bill upon the breast, and remain quiet for some time.

FIG. 5.—Wheat falling and lodging as a result of infestation by the Phœnix billbug, the work of which is done at the base of the stems, like the work of the blue-grass billbug.

LIFE HISTORY OF BILLBUGS IN GENERAL.

Billbugs in general require one year in which to complete their development, as follows: The adult female which has hibernated emerges in the spring, feeds, mates, and lays eggs. Usually it cuts a cell in a plant stem in which to deposit its egg (figs. 6, 7, 15, *b*, and 18, *b*) and egg-laying covers a period of about two months during late spring and early summer. From 4 to 15 days after the eggs are laid the grub hatches. This grub (figs. 4, 8, and 19) is a small, white, maggot-like worm with hard brown or yellow head, and looks very much like the maggots one often discovers upon biting into a chestnut. It feeds for several weeks, and when fully fed changes to the pupa or resting stage (figs. 9, 15, 18, *c*, and 20). Several days afterwards the pupa changes to an adult (figs. 10–14, 17, 18, *c*, 21, and 22), which

may pass the winter in the pupal cell or may come forth and lead an active life for some time before becoming dormant for the winter.

BLUE-GRASS BILLBUG.[1]

The blue-grass billbug (fig. 10) is one-fourth to five-sixteenths of an inch in length. It is a widely distributed upland species, usually infesting timothy and blue grass, but often injuring wheat and occasionally oats, barley, and rye, and probably several wild grasses. The adult or beetle works frequently on corn planted on spring-plowed old sod, dwarfing it more frequently than killing it. The

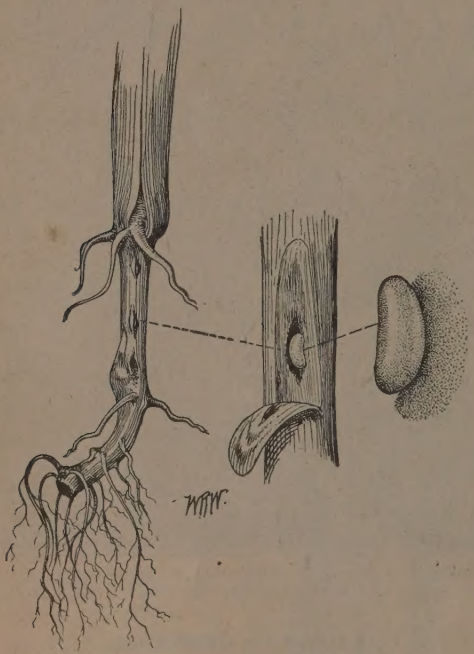

FIG. 6.—Egg punctures of the Phœnix billbug in base of wheat plant, with egg shown in cell in opened stem, and with egg further magnified.

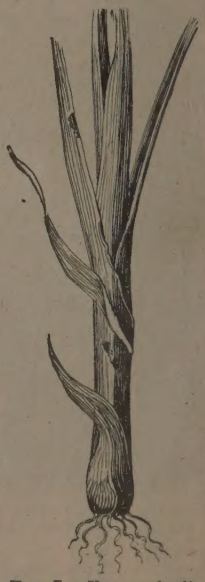

FIG. 7.—Egg or feeding puncture, probably of the "curlew bug," in stem of sedge.

injury caused by grubs in blue-grass is seen frequently, but the potential injury is the unseen, widespread cutting of grass root-bulbs and rootlets, resulting in an annual hay and pasture loss and premature failure of the sod.

When the grub works in timothy it may excavate the stem for about 3 inches at the base, or the corm, or both, or it may eat the root fibers and corm from beneath. The hollowed corm often may be found packed with the castings of the grub, which are called "frass,"

[1] *Sphenophorus parvulus* Gyllenhal.

and where infestation is serious the excavated ends of a large percentage of the corms can be seen by pulling up a timothy sod when the soil is dry and examining it from beneath. Pupation occurs either in the corms or in the soil. In attacking rye, the grub eats out completely the substance of the nearly solid stem (fig. 4) up to the second joint, then goes to the roots, and sometimes destroys all the roots of a whole stool. The larval period approximates 23 days, the pupal period about 8 days in midsummer, and the entire period from laying of the egg to the appearance of the beetle approximates 45 days. This billbug is able to remain submerged in water for days without injury.

FIG. 8.—Grub of maize billbug. Twice natural size. (Kelly.)

FIG. 9.—Pupa of the Y-marked billbug. Greatly enlarged.

FIG. 10.—Adult blue-grass billbug. Much enlarged. (Chittenden, unpublished.)

The blue-grass billbug probably is distributed throughout the country; at least it is known from Canada to Florida and Texas and from the Atlantic coast to South Dakota.

CORN BILLBUG.[1]

The corn billbug (fig. 11) has habits and life history practically the same as those of the blue-grass billbug, but it is larger and more robust. It often occurs in the same timothy clusters with the blue-grass billbug, but the blue-grass billbug prefers the higher portions of the field and the corn billbug the lower portions.

This billbug has been known to destroy the first and second plantings of corn and to injure the third on a spring-plowed, upland, 13-

[1] *Sphenophorus zeae* Walsh.

year-old timothy meadow, remote from either stream or swamp. It cripples much of the corn by making it sucker and fail to produce ears. This species is charged with being one of the prime causes of the early failure of meadows, the injury resulting from the work of both grubs and adults, but more often the former.

FIG. 11.—Adult corn billbug. Much enlarged. (Chittenden, unpublished.)

While this usually appears to be an upland species, great numbers frequently have been collected in drift along overflowed streams. It occurs from Massachusetts and Michigan to Florida and Kansas and probably farther west and southwest.

The life cycle of the corn billbug, from laying of egg to issuing of adult, consumes about 52 days. The egg stage lasts approximately 9 days, the grub stage frequently about 38 days, and the pupa stage approximately a week.

In the field eggs are laid promiscuously on a leaf near the base of its sheath, on or in the center of shoots, and in cells excavated in the timothy corms.

FIG. 12.—Clay-colored billbug. Much enlarged. (Walton.)

CLAY-COLORED BILLBUG.[1]

The clay-colored billbug (fig. 12) is a large species, measuring more than half an inch in length. It is a swamp-inhabiting insect and, in Illinois and Indiana, has a life history about as follows: The egg is laid in the stalk about 4 inches above the young bulb, egg laying

[1] *Sphenophorus aequalis* Gyllenhal.

taking place from May till the 1st of August. The grub bores down the stem and to the old bulbs, even passing through a fourth inch of soil to reach the old bulb (fig. 13). Pupation takes place within the larval excavations in the bulbs, and adults issue by August 21 and remain in the pupal cell over winter, appearing above the ground by the time the corn is up in the spring.

Injury by the clay-colored billbug to corn is wrought in the same manner as by the others, but instead of causing it to sucker it usually kills the plant attacked.

This species occurs throughout the United States from Canada to Arizona and eastward to the Atlantic coast. The adult has been found feeding on corn, millet, foxtail,[1] club rush or dark green bulrush,[2] river bulrush,[3] bristly nutgrass or straw-colored Cyperus,[4] and common reed grass,[5] and the grubs breeding in rushes, sedges, and reeds.

FIG. 13.—Characteristic work of clay-colored billbug in roots of river rush. The presence of these root nuts in corn land should be a warning of the probable presence of the billbug.

MAIZE BILLBUG.[6]

The maize billbug (fig. 14) is four-tenths to six-tenths of an inch long. It is broad and proportionately thicker through the body than any of the other billbugs. It is dark reddish brown or black when not covered or colored with mud, and the wing covers have several raised, rounded, smooth lines running about two-thirds of the way back, these often showing through the mud. Its double injury to corn, as adult and as grub, was observed as early as 1855, and fortunately there are only one or two other species injurious in both adult and larva stages.

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[1] *Chaetochloa* sp.
[2] *Scirpus atrovirens* Muhl.
[3] *S. fluviatilis* Torr.
[4] *Cyperus strigosus* L.
[5] *Phragmites phragmites* L.
[6] *Sphenophorus maidis* Chittenden.

The adult injures young corn plants by piercing the stem and eating out a quantity of tissue. This causes the plant to sucker (fig. 3), thus providing young, succulent corn for the billbug for some time after uninjured corn has become too hard for it. These crippled plants are nonproductive.

FIG. 14.—The adult maize billbug. Four times natural size. (Kelly.)

The adult billbug also injures the corn by making an excavation for the egg (fig. 15, *b*) in the stalk at or below the surface of the soil. These eggs are creamy white and somewhat kidney-shaped. They hatch in from 7 to 12 days. The grub (fig. 8) feeds within the cornstalk and in the main root, and after 40 or 50 days makes its pupal cell in the upper part of the main root and pupates (fig. 15, *a*). The grub injury to corn dwarfs the plant (fig. 16) and sometimes kills it. The pupal period lasts 10 or 12 days.

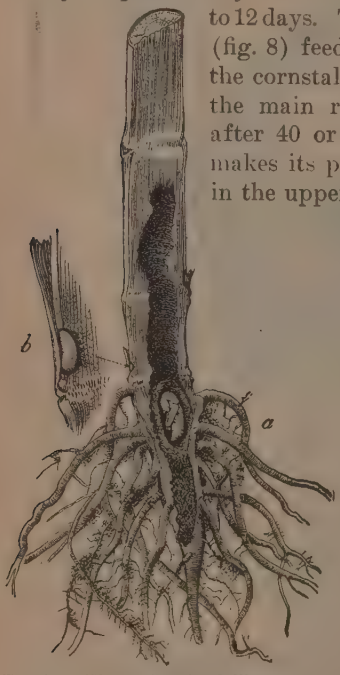

FIG. 15.—Work of maize billbug in corn stubble, showing (*a*) the grub excavation and the pupa in the pupal cell near the top of the main root, and (*b*) egg at or below surface of ground, and egg enlarged. (Kelly.)

The food plants of the maize billbug are corn and grama grass.[1]

The maize billbug, in Kansas, lays its eggs in June, the grubs work from early June to September, and pupæ occur during late August and early September, apparently always in the larval excavation. The early developing adults leave the pupal cells and disappear for hibernation elsewhere; those maturing later hibernate in the grub excavations and may be destroyed by carefully pulling up and burning the corn—stubble and roots.

In Kansas, South Carolina, and Alabama the species is very destructive, injuring corn in both the adult and grub stages. It occurs also in Michigan and Texas.

[1] *Tripsacum dactyloides* L.

FIG. 16.—Corn plants showing effects of feeding of maize billbug in the field. Plant at left not injured; the two at right attacked by grubs. (Kelly.)

"CURLEW BUG."[1]

The "curlew bug," or southern corn billbug (fig. 17), is a lowland species averaging about three-eighths of an inch in length. The beetle usually is mud colored, but as the natural coating, which is of a brown color with gold in favorable lights, wears off, the more prominent bumps become polished and black. A large dent in each wing-cover near the base and a prominent callous hump near the posterior end of each wing-cover will help in identifying this billbug.

Complete destruction of entire fields of corn by the "curlew bug" is frequent in the South Atlantic States, where the greater portion of the damage is wrought by the grubs feeding in the base of the cornstalk and in the taproot. Similar injury by these grubs is recorded from New Mexico, Oklahoma, and Kansas. After corn, the crops most injured are rice and peanuts, in the order given. Rice crops occasionally are abandoned on account of this pest.

FIG. 17.—The adult curlew bug. Four times natural size. (Webster.)

The eggs are laid in corn (fig. 18, *b*), chufa[2] or yellow nut-grass, bristly nut-grass or straw-colored Cyperus,[3] and another nut-grass,[4] and probably all species of plants in which grubs have been found. As many as 447 eggs have been recorded as deposited by one female. The beetles lay their eggs in the stalks of young corn, either under the surface of the soil or within an inch above, and after the corn is older they deposit their eggs in the nut-grasses.

During the egg-laying season the adults rest under clods of earth, stones, and old cornstalks. Travel by flight is very rarely observed. The early maturing beetles leave their pupal cells in a few days and soon lay their eggs. The egg period is from 4 to 12 days, and the grub period from less than 39 days in midsummer to more than 71 days in autumn, the development being quicker with abundance, and slower with lack of suitable food. The grubs (fig. 19, *a*, *b*) have been found in corn, sedges,[5] grasses,[6] rice, and peanuts.

The work of the grub in corn is well shown in figure 18, *c*.

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[1] *Sphenophorus callosus* Olivier.

[2] *Cyperus esculentus* L.

[3] *Cyperus strigosus* L.

[4] *Cyperus rotundus* L.

[5] *Cyperus esculentus* L., *C. strigosus* L., *C. rotundus* L., *C. cylindricus* Britt., *C. flavicomus* Michx., *C. ovularis* Michx., *C. exaltatus*, and *Carex frankii* Kunth.

[6] *Tripsacum dactyloides* L. and *Panicum capillare* L.

Pupation requires about 6 to 8 days. The pupa (fig. 20) is white to cream color, and varies in length from seven-sixteenths to five-eighths of an inch. Pupæ may be found within about six weeks after the first eggs are found and until late autumn. Where pupation occurs in corn the position of the pupa (fig. 18, *c*) is lower down than that of the maize billbug (fig. 15, *a*), making the hand pulling of roots useless because the tip, containing the beetle, so often breaks off and remains in the ground.

The adults live from one summer to the following, and their presence is easily ascertained in midsummer in the Wabash and Mississippi Valleys, and probably throughout its territory, by the dead centers, either leaves or flower stalks, in nut-grass plants, even when this troublesome billbug is not, at the time, destructive to corn.

FIG. 18.—The "curlew bug": *a*, Corn plant attacked by adult insect, showing crippled stalk, perforated leaves, and leaf broken at perforations; *b*, egg as placed in young corn plant, and enlarged; *c*, pupa in grub excavation, and adult in excavation near tip of main root, as for hibernation. (Webster.)

Its range is from Maine to Arizona, and from Wisconsin to Florida, and probably coincides with that of its favorite nut-grass.

TULE BILLBUG.[1]

The tule billbug is the largest of all the injurious species, being about 1 inch in length and is dark brown with light markings on the sides and under surface. A color variety[2] differs only in having additional white markings on its back.

[1] *Sphenophorus discolor* Mannerheim. [2] *Sphenophorus pictus* LeConte.

This species is not aggressive, but when the farmer incautiously encroaches upon its domain it attacks cultivated crops, such as barley, oats, and wheat.

It occurs in the tule marshes[1] of California from San Diego to north of San Francisco. The grub works in the tule, and the adults begin to work early in the spring, causing losses to growing grain planted adjacent to, or on, recently reclaimed tule swamps.

Although recognized since 1857, its injuries to crops thus far have been limited to the immediate vicinity of the swamps, and greatest on newly reclaimed land, but as it is not known to breed in cultivated crops or to require more than one season for development, clean cultivation for one year eliminates it from such land. When grain

FIG. 19.—*a*, Grub of the "curlew bug"; *b*, head of same; *c*, head of grub of the maize billbug. Much enlarged. (Webster.)

FIG. 20.—Pupa of the "curlew bug." Much enlarged. (Webster.)

is planted within its range, it cuts the heads of the growing stalks at the boot, thus killing the top.

CAT-TAIL BILLBUG.[2]

The adult cat-tail billbug (fig. 21) measures from seven-sixteenths to five-eighths of an inch in length and the depressions on its back are coated with pale clay-yellow hairlike velvet.

This billbug has long been considered among the most important of billbug depredators in corn. It was recognized as early as 1807, and by 1873 it was known from Canada to Louisiana and from the Atlantic to the Pacific. It is a lowland species, usually working on cat-tails and flags, but becoming of great economic importance whenever

[1] The dominant tule is a club rush, *Scirpus occidentalis* Chase.

[2] *Sphenophorus pertinax* Olivier.

infested waste land is reclaimed for corn growing. The beetle is extensively destructive to growing corn, burrowing into the soil and attacking the stalk from below the surface of the ground and causing the plant to dwarf and fail to ear, rather than to die outright. It thrives equally well in a blue-grass sod. The adults work from April to August and rest hidden in the soil. Egg laying begins by the latter part of June and the eggs usually are placed about cat-tail and calamus flags. The grubs are not found in corn, and they are believed to winter over to some extent in the pupa stage, although generally changing to adults about the last of October.

FIG. 21.—The adult cat-tail billbug. Much enlarged.

DESTRUCTIVE BILLBUG.[1]

FIG. 22.—Adult of the destructive billbug. Much enlarged. (Chittenden, unpublished.)

The destructive billbug (fig. 22) is from one-fourth to three-eighths of an inch in length, is black, thickly covered with a dull clay-colored or brownish coating, and is rather rough in appearance.

This billbug was well named and is one of the more common species occurring in cornfields throughout its range, which extends from New Jersey to Kansas and Texas. It is especially destructive in Missouri. Observations indicate that the pest is or may become destructive in the larva stage to timothy and wheat. A single female is able to lay at least 30 eggs. Adults are known to live nearly a year. The destructive billbug frequently is found in the same fields as the "curlew bug" and associated with it at the same feeding plants and

[1] *Sphenophorus destructor* Chittenden.

the same shelters, and usually is second in abundance, at least in Indiana and Missouri.

Y-MARKED BILLBUG.[1]

The Y-marked billbug is from one-fourth to two-fifths of an inch in length and is black, densely punctate on the back between the head and wing covers and on the ridges of the wing covers. It is destructive to timothy and corn. The adult injures wheat (fig. 23) and corn in the usual billbug fashion. It is active from April to August or later, laying eggs until August 30, in Missouri. The grub develops in wheat and timothy but its habits are not well known. An illustration of the pupa is given in figure 9, page 9.

The adults are frequently found in drift from high water. Usually they are found in cornfields infested with bristly nut-grass. The species ranges from Maine to Florida and from Wisconsin to Texas and is found only on low land.

FIG. 23.—Work of the Y-marked billbug grub in the base of wheat stems, with frass left in the excavations.

PHŒNIX BILLBUG.[2]

The Phœnix billbug measures about three-tenths of an inch in length and is variable in color, ranging from light tan, when first mature, to a deep brown or black with a velvety coating of gray to pale reddish. This insect has been known since 1904. It occurs in California and is very destructive in the Salt River Valley of Arizona, in the vicinity of Phœnix, hence its name.

This billbug begins its work early in the spring, often committing serious injury which is not noticed until it is too late to restore the crop, although prompt irrigation may save part by stimulating growth. The beetles congregate, as many as 12 to a single plant, on tender stools of wheat or barley planted on or near to infested old Bermuda-grass sod. They puncture the stems and eat out the soft interior tissue. This work continues from early spring, and even during the warm spells in winter, until the middle of June. Part of the damage by the beetles is done when they excavate places in the plant—usually in the stem, but when the plants are quite young

[1] *Sphenophorus venatus* Say. [2] *Sphenophorus phoeniciensis* Chittenden.

often also in the tender tip—in which to lay their eggs. When the egg excavation or egg puncture is in the tip of the young plant the plant dies. Many stems die early from the punctures, many which remain for harvest produce small heads, and a substantial portion of the stalks fall just before harvest time on account of the damage done to the stems (fig. 7). The economic importance of the pest is measured by crop losses in wheat or barley up to about 100 per cent. Almost without exception only one egg is laid in a stem. The eggs laid in March and April hatch in from 8 to 13 days; those laid in May in from 6 to 8 days. Pupation occurs in compact earthern cells in the soil and rarely in larval excavations in sugar cane from early June to autumn. Development from the hatching of the egg to the appearance of the adult requires about two months.

LITTLE BILLBUG.[1]

The little billbug is from one-fifth to one-fourth of an inch long. It is dull black, covered with a rich brown pile, which appears when soiled as a pale clay-colored coat. On the forward part of its back are numerous wide, shallow pits.

This little fellow is as sly as the corn billbug in tapping the farmer's till, and uses the same underground system of theft. It occurs from New York to Texas and from Illinois to Florida. The known food plants are timothy, quack grass, and wild rye.[2] It has been found destructive to timothy in Indiana, Ohio, Kentucky, and especially Michigan, where serious damage to sod is common. In the vicinity of Pittsburgh, Pa., this is the most abundant billbug. The amount of damage wrought by it can not be easily determined, for it is very inconspicuous as a beetle and works beneath the surface of the sod. The grub of the little billbug hollows out the corm of timothy plants.

The egg period is known to be less than 8 days, the grub period between 27 and 33 days, and the pupal period 7 days or more. The entire development is frequently accomplished in less than 60 days, though occasionally requiring about 70 days.

NATURAL ENEMIES OF BILLBUGS.

Although the grower can not wait for nature unassisted to control the insect pests which are destroying his crops, nevertheless the good work of the natural checks is by no means to be ignored. These checks are insect, worm, and fungus parasites, toads, birds, and doubtless other insect-eating animals.

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[1] *Sphenophorus minimus* Hart. [2] *Elymus virginicus* L.

INSECT PARASITES.

Wasplike insect parasites in the grub stage feeding on the outside of billbug grubs have been found at many places and doubtless render considerable aid at times.

A very showy parasite[1] with black wings and red body has been reared from "curlew-bug" grubs from Athens, La Fayette, and Muncie, Ind.

TOADS.

The American toad is a very efficient consumer of insects, adapting itself effectually to farm, garden, or urban hunting grounds. In Arizona 4 out of 10 toads killed from April 4 to July 22, 1913, and dissected to ascertain whether or not they fed on Phoenix billbugs, contained 13 of these destructive insects.

BIRDS.

Many kinds of birds have been found feeding on billbugs. Not only should these be given consideration for the good work they do incidentally when flocks of them gather where the pests are especially numerous, but they should be fostered and protected to increase the value of their services. The elimination of vagrant cats and the placing of proper restrictions upon those valued as house pets will result in the saving of the lives of many birds, as will also the provision of food and shelter for them in winter.

Crow blackbirds, redheaded woodpeckers, and wood pewees are known to feed on the corn billbug and other billbugs, the bobwhite on the corn and blue-grass billbugs, the kingbird on the corn billbug, the English sparrow and various other birds on the blue-grass billbug, the cardinal and phoebe on other billbugs, and the nighthawk on the "curlew bug." The song sparrow and western vesper sparrow, redwing and thick-billed redwing blackbirds, meadowlarks, crow, catbird, brown thrasher, Wilson phalarope, avocet, black-necked stilt, pectoral sandpiper, killdeer, upland plover, and flickers feed on undetermined billbugs, and several of the shore birds mentioned appear especially fond of them.

MEANS OF CONTROL.

Serious injury to cultivated crops by billbugs may be easily prevented by the following simple beneficial cultural practices: Clean cultivation, fall plowing, planting of crops which are immune to billbug injury, proper rotation of crops, improved drainage of damp lands, and community action in adopting control measures.

[1] *Zaviplo belfragei* Cresson.

Clean cultivation in this case means the elimination of nut-grasses and other sedges, and flags, cat-tails, and other rushes, together with other moisture-loving wild grasses, from ground intended for corn. Where possible, the first season after breaking, plant on such ground some crop which is known to be immune to billbugs, such as cotton, cowpeas, soy beans, flax, or Irish potatoes.

Plow damp lands, intended for corn growing, in the fall of the year and see that proper drainage is provided, so as to prevent winter-flooding, where at all possible.

Adopt a suitable system of crop rotation, in which corn will be grown on the same land not longer than two years in succession. In the South cotton, soy beans, or cowpeas may be substituted, if clean cultivation is practiced in order to eliminate sedges, and will greatly aid in controlling billbugs. In the North the growing of crops such as soy beans, flax, or vegetable crops such as potatoes will serve the same purpose. The first year after breaking do not plant corn on ground which has been used for the growing of chufas. This crop is grown in certain portions of the South as forage for hogs, but serves as a breeding ground for several species of billbugs, and serious injury may be expected if corn is planted on such land the first year following this crop.

Thorough drainage of infested land is always of great benefit. Tile drainage is preferable, but where this is impracticable open ditching is beneficial. The addition of lime to damp, sour land usually is necessary, and tends to render such land less suitable for the growth of sedges, rushes, and other moisture-loving plants, which are the natural food of billbugs.

CONTROLLING THE CLAY-COLORED BILLBUG, THE BLUE-GRASS BILLBUG, AND THE CORN BILLBUG.

The clay-colored, blue-grass, and corn billbugs are known to complete their development in bulbs or tubers thrown out by the plow and exposed to the sun for more than a month in the summer. It is therefore not advisable to attempt to eliminate them by plowing during the warm months. Fall plowing, however, has proved to be an excellent means of destroying them. As these billbugs normally feed in the tubers or nuts of the river rush and in sedges it is absolutely necessary that all rushes, sedges, and water-loving grasses be eliminated from infested fields if complete control is to be effected.

CONTROLLING THE PHOENIX BILLBUG.

As the Phoenix billbug can not complete its life history in wheat or barley, but requires Bermuda grass or other large grasses in which to finish its growth, the elimination of Bermuda and other grasses

and sedges from grain fields results in the subsidence of injury by this beetle.

CONTROLLING THE "CURLEW BUG" AND THE MAIZE BILLBUG.

The maize billbug and the "curlew bug" are easily eliminated from cornfields by practicing a suitable rotation of crops, alternating corn with cotton or other cultivated crops, such as Irish potatoes, upon which they can not live (fig. 24), and practicing clean cultiva-

FIG. 24.—Work of the "curlew bug." The portion of corn to the left is following cotton of the preceding year and that to the right is corn following corn infested with the "curlew bug" the preceding year. A nonsusceptible crop, such as cotton or flax, in rotation with corn, saves corn from billbug losses. (Webster.)

tion. All chufa or other sedges must be destroyed if complete success is to be secured.

CONTROLLING OTHER KINDS OF BILLBUGS.

The control methods for the other kinds of billbugs which have been discussed are practically identical with those which have been mentioned.

OTHER REMEDIAL MEASURES.

Where the preventive measures mentioned previously have not been practiced, it is sometimes possible to prevent the maximum injury from billbugs by using certain palliative methods, such as planting corn at the earliest safe date for the "curlew bug," or wheat or barley early in the fall in the case of the Phoenix billbug.

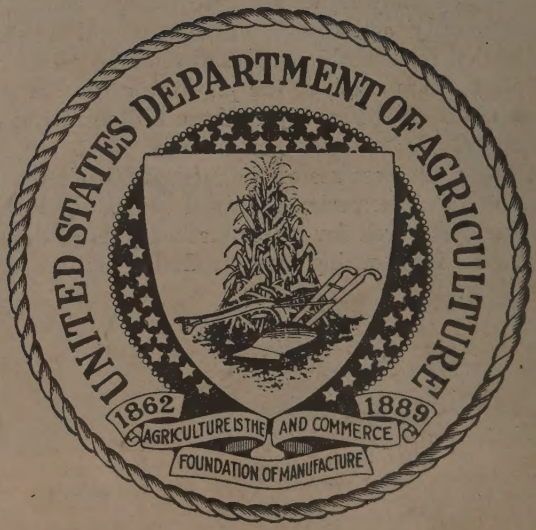
In corn which has been injured by billbugs, causing the "buds," or growing points, to break over or twist (fig. 2), the "buds" may be im-

mediately clipped with scissors or shears just below the break, as this treatment frequently prevents a partial loss of the crop. The application of suitable fertilizers also enables plants to overcome injuries which have already occurred from billbugs. Before applying such fertilizers, however, the grower will do well to consult the Bureau of Soils of the U. S. Department of Agriculture as to the character of fertilizer to be applied, which should be that best suited to meet the requirements of the particular soil involved.

COOPERATION.

The cultural practices described have proved effective locally, but at least one thing more is necessary to render them fully effective, namely, community action. Community adoption of a two-year maximum period for timothy, early fall plowing, either of cultivated sod or of plain swamp sod, or the planting of flax or of cotton for the first crop, will so reduce injury from billbugs as to render them of little account.

In short, make the best use of the methods that have proved their value, and let every experience gained regarding billbug injuries aid in the further search for better methods, better dates for operations, and means for securing more profitable first crops.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